Pic2Mag's Field Calculator

Free Beta Version 1.0 Multithreaded by Michael Snyder 06/09/2019

You draw virtual magnets and Pic2Mag draws the fields! (tm)

Windows Usage, place the executable FieldCalc.exe into any folder and double click FieldCalc.exe. When you first download the Field Calculator program, you should run a antivirus scan on it before you run it.

You can download the program from this URL - http://www.pic2mag.com/Pic2Mag_FieldCalc_v1.zip

The Pic2Mag's Field Calculator(tm) is a Windows Form application build using Microsoft's partial trust ClickOnce security framework and should run on nearly any windows computer with Microsoft .NET Framework 4.5.2 or better.

This version of the program REQUIRES a large high resolution monitor to see all the buttons. The present application is locked to a resolution of 1164x896 pixels, and ideally needs a1920x1080 or a 1600x900 screen to run it.

Note if one has changed their Windows Icon/Font DPI scaling from the 100% default setting; to the 125% Medium or 150% Larger settings then this image size increase ALSO applies to Windows Form applications. Windows will draw some of the lower application buttons off the screen. The present solution is to use a bigger screen and/or use the default Icon/Font DPI size settings. This problem will be fixed in the next version of the program with dynamic window sizing. :)

Figure #1 - The Pic2Mag's Field Calculator Introduction Screen.

Figure #2 - Pressing the 'Calc Vector Field' Button.

Pic2Mag uses colors in a graphics file to represent magnetic materials with different magnetic moments.(tm) The program looks for certain RGB values in the png file and when it finds the exact match the program plots that pixel as a one millimeter cube permanent magnet with a defined magnetic moment angle. Different colors have different magnetic moment directions and angles.

In Figure #2, The Introduction screen is made up of red and blue pixels which represent one millimeter cube permanent magnets with either the North (red) or the South (blue) poles facing the viewer. We will go ahead and click the purple 'Calc Vector Field' button on the left to start the processing of the image.

Clock Color Spin Vectors(tm) on a Black Background (0 0 0)

XY Plane Color RGB values

12:00 o'clock light yellow	**(255 255 128) 000 Degrees (up)**
1:30 o'clock orange	**(255 128 000) 045 Degrees (upper right)**
3:00 o'clock aqua	**(000 255 255) 090 Degrees (right)**
4:30 o'clock purple	**(128 000 255) 135 Degrees (lower right)**
6:00 o'clock dark green	**(000 128 064) 180 Degrees (down)**
7:30 o'clock brown	**(128 064 000) 225 Degrees (lower left)**
9:00 o'clock green	**(000 255 000) 270 Degrees (left)**
10:30 o'clock lavender	**(255 128 255) 315 Degrees (upper left)**
blue z axis into page south	**(000 000 255) (away from viewer)**
red z axis out of page north	**(255 000 000) (towards viewer)**
dark purple monopole sink	**(128 000 128) (away from viewer)**
pink monopole source	**(255 000 128) (towards viewer)**

You can edit your 1280x1280 png file in any graphics editor as long as you set the correct RGB colors for each magnet and then load it into the Field Calculator for processing. The Author uses AutoCAD to draw precise magnet layouts and then MSpaint to color the layouts before processing them with Pic2Mag.

The Field Calculator program has basic graphics editing capabilities and can be used for drawing disc and cube magnets on the screen and also playing the interactive 'what if' game of what happens if I add a magnet to this spot, etc.

Depending on the number of processed pixels, Pic2Mag's Field Calculator can take 30 seconds to 10 minutes to process an image. The reason it takes so long is that each pixel interacts with every other pixel in the image. For every pixel, the program first computes the complete 1280x1280 magnetic field vectors for that pixel; then using the superposition principle adds the results for all the pixels.

The good news is that you can save the vectors for a processed image and reload them at a later time, using the 'Export' and 'Import' buttons on the right hand side. For example an instructor could process images ahead of time and have students load the vector fields for a starting point in a lab exercise.

In Figure #3, we can see the processing has finished in 174 seconds and the program has drawn isopotential lines showing the relative strength of the magnetic field. You can have your students easily check the equal potential lines by clicking on point on a isopotential line and writing down the I,J,K vectors (shown on the right hand side) for that point, then picking another point on the same line. Anywhere on the line, I*I + J*J + K*K should give very similar values. Go ahead and click the 'Plot Compass Needles' Button on the left hand side.

Figure #3 - Showing the Isopotential lines of a processed image.

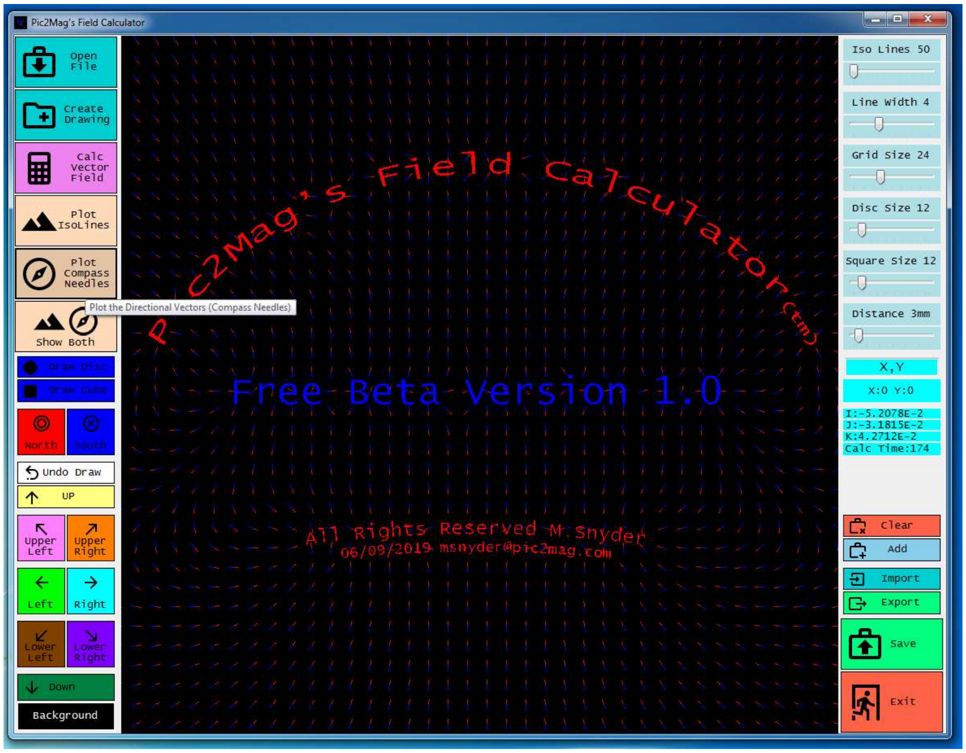


Figure #4 - Showing the compass needle plot of a processed image.

In Figure #4, we can see the results of plotting the Compass Needles. Notice that the red part of the Compass Needle always points the closest North pole and the blue part of the Compass Needle always points to the closest South pole.

The Compass Needles are really just the I and J vectors of a selected point plotted as an unscaled vector using a grid layout. The plotted directional vectors show the direction of the magnetic field but not the magnitude of the field.

One question that I have received is that because the divergence of magnetic field equals zero, can two compass needles point at each other? The answer is yes that two compass needles can point at each other because they are being plotted in two dimensions, and have the same limitations of a physical compass.

For example if you lay a large ring magnet on a table and place a number of physical compasses inside the ring magnet; clearly one pole of each compass needle will point to the closest part of ring magnet, and the other pole of the each compass needle will point to the center of the ring. Viewed from above on a 2d plane, the physical compass needles point at each other inside the perimeter of a ring magnet. Basically the divergence being equal to zero is still preserved on a 2d plane by the non-plotted K vector which points into the Z direction.

The number of Compass Needles that the program plots can be set using the 'Grid Size' Control on the upper right side of Field Calculator application. Go ahead and press the 'Show Both' button in the middle of the left hand side of the application.

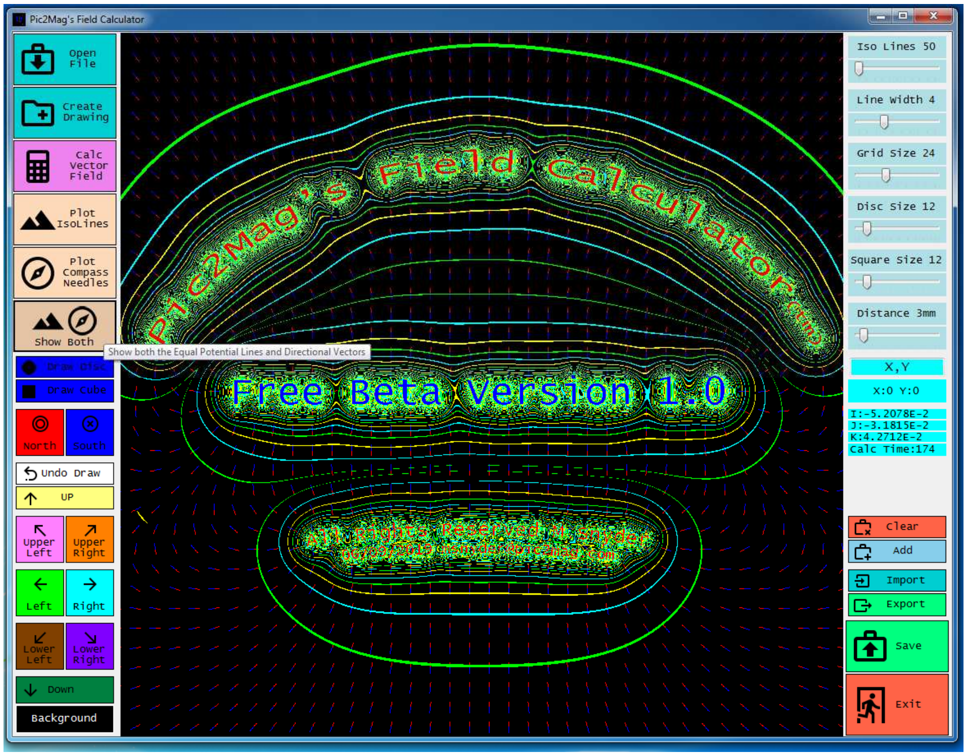


Figure #5 - Showing both the Isopotential lines and Compass needles

In Figure #5, we can see both the relative strength of the magnetic field from the Isopotential lines and the direction of the magnetic field from the Compass needles. The number of Isopotential lines and width of the lines can be set using the 'Iso Lines' and 'Line Width' controls which are on the upper right hand side of the program.

We can click anywhere on the image, or enter Cartesian coordinates 'X,Y' values in the teal textbox in the middle of the right hand side of the application to display the I,J,K vectors for that point.

In this document, +X,+Y,+Z are directions. +X starts in the middle of the screen and runs to the right hand size of the screen. +Y starts in the middle of the screen and goes up to the top of the screen. +Z starts in the middle of the screen and approaches the viewer out of screen.

The references to I,J,K vectors means the float32 values for a vector located at an X,Y,Z indexed position. I think of I,J,K as databases that have millions of stored float32 values located at X,Y,Z integer indexes. Implicit in the definitions of the X,Y,Z indexes and I,J,K vectors are $\hat{i},\hat{j},\hat{k}$ one millimeter unit vectors.

It should be noted that the program uses an internal μ constant that equals one to decrease the number of needed cpu operations; and that the computed I,J,K vectors shown in the program need to be appropriately scaled with a measured μ constant to match real world experiments and/or gauss readings.

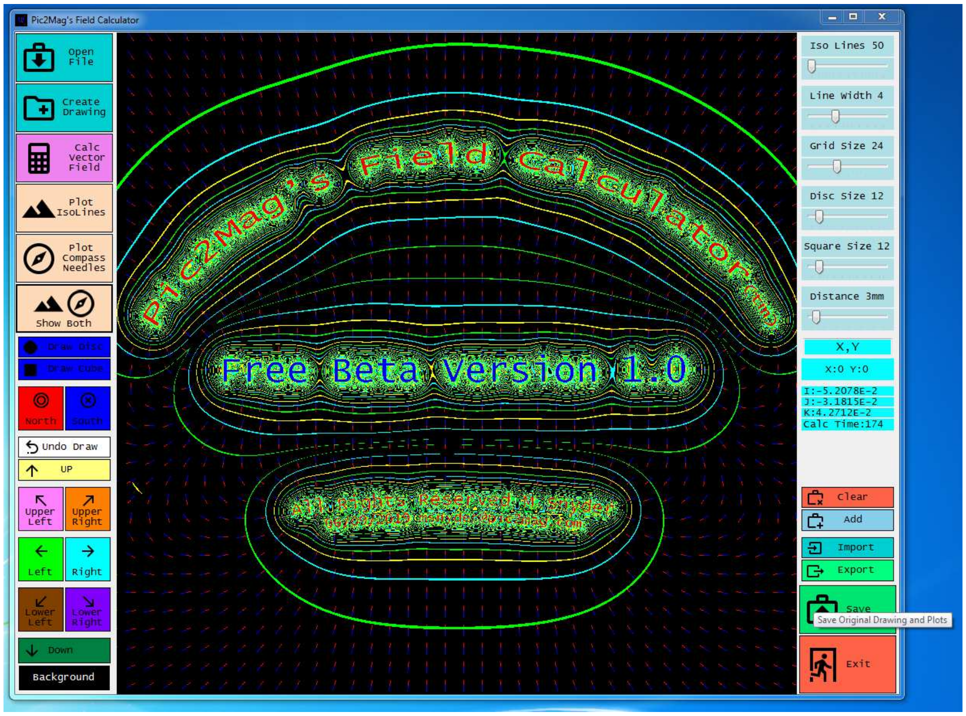


Figure #6 - Showing the 'Save' button on right hand side.

Now that we have plotted both the Isopotential lines and Compass needles we can hit the 'Save' button on the lower right hand side of the application. The system save dialog will ask for a file location and file name and will save four files with similar names to the location that you pick.

The original file is saved with the given name, then a plotted Isopotential lines version called '_iso' and then two combined Isopotential lines and Compass needles versions. One version with a black background called '_scr', and one version with a white background called '_prn' which is meant for printing.

Pic2Mag's Field Calculator can also draw it's own magnet arrays on the screen by pressing the 'Create Drawing' on the upper left hand side which clears the last drawing from memory.

As seen in Figure #7, First press 'Create Drawing to clear the screen then press the 'North' button to pick a color and magnetic moment direction, then click anywhere on the screen to place your first magnet.

The magnet sizes can be picked using the 'Disc' and 'Square' controls on the middle left hand side of the program.

Seen in Figure #8, we can place our second magnet by first clicking the 'South' button to the set the color to blue, and then pressing the 'Draw Cube' button and clicking on a spot in the center screen.

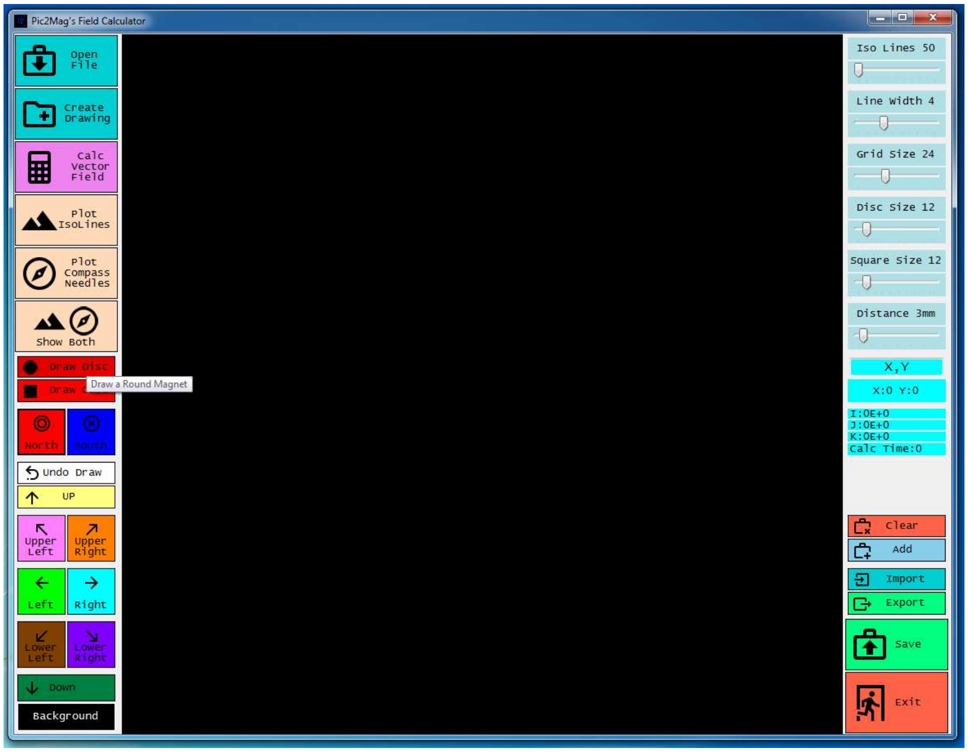


Figure #7 - Creating a new drawing and drawing a magnet.

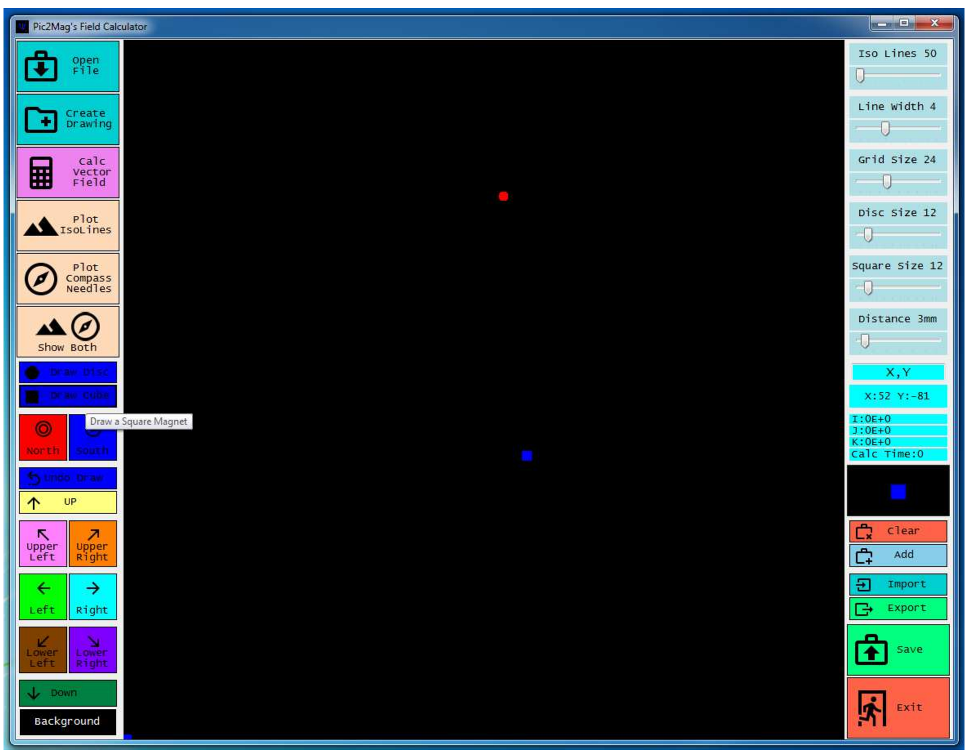


Figure #8 - Drawing round and square magnets on the screen.

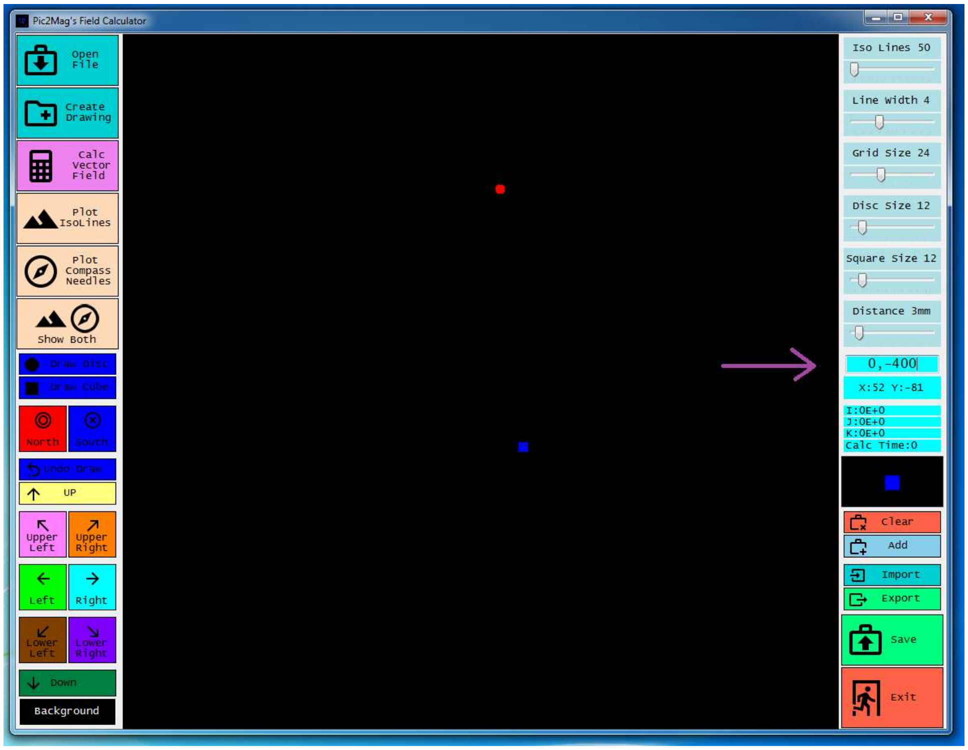


Figure #9 - Using the textbox to enter magnet X,Y coordinates .

In Figure #9, we are doing something different. First we pick a color, in this case first the blue 'South' button, then we press the 'Draw Cube' button but instead of clicking on the screen to pick a position for the magnet, we click on the teal colored textbox on the middle right hand size of the program.

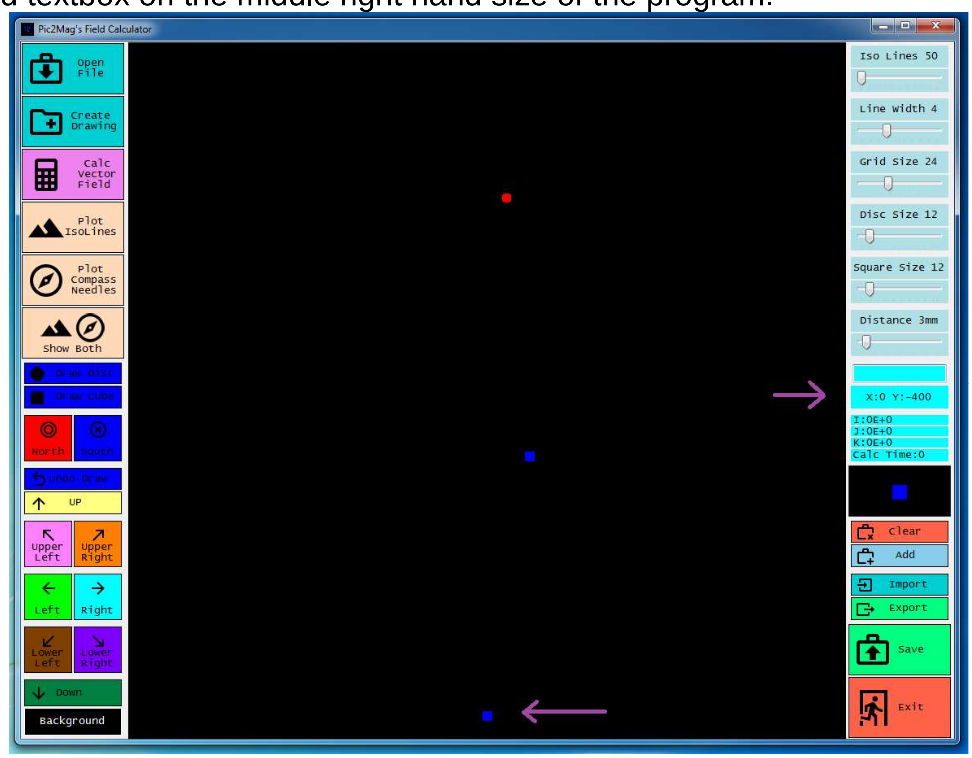


Figure #10 - Positioning a magnet using a textbox.

We can enter X,Y coordinates and have them accepted as mouse clicks for positioning magnets. In this case we entered the position of 0,-400 and the new magnet is shown in Figure #10.

Of course we can now process these three magnets by pressing the 'Calc Vector Field' button on the upper left hand side and the results are shown in Figure #11.

Figure #11 - Calculating the vectors and Isopotential lines of the three magnets.

Clearly the textbox method is useful for laying out precise magnet arrays.

For example, first we press the 'Create Drawing' button to clear the screen.

Second we press the 'South' button, then the 'Draw Disc' button then enter into the textbox 100,100.

Third we press the 'South' button, then the 'Draw Disc' button then enter into the textbox -100,-100.

Forth we press the 'North' Button, then the 'Draw Cube' button then enter into the textbox 100,-100.

Fifth we press the 'North' Button, then the 'Draw Cube' button then enter into the textbox -100,100 and then press the 'Calc Vector Field' button.

The result is seen in Figure #12, the traditional quadrupole magnetic field, which has four poles.

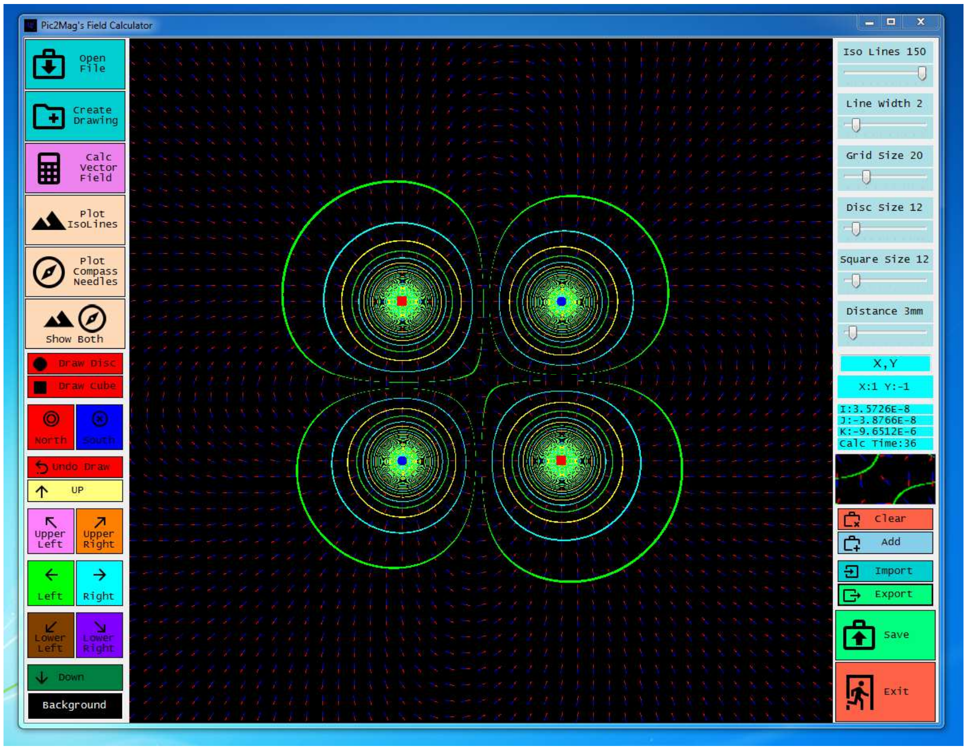


Figure #12 - Plotting the traditional quadrupole magnetic field.

The remaining colors on the lower left hand side are just for different magnetic moment directions. For example imagine you have a cube magnet sitting on a table with the south pole surface touching the table. That means the north pole surface is facing the viewer and we would use a red color to represent it.

If we turn the cube magnet on it's side then we could use the yellow color to represent the magnet with it's north pole surface pointing away from viewer on the 2d plane of the table. You can imagine each drawing color as different directions of cube magnets sitting on a table.

Next we put a sheet of glass over the cube magnets and take gauss readings on the top surface of the glass. How thick is the glass?

Let's say it's 3mm thick. On the upper left hand side of the application is a 'Distance' setting control which allows you to set the distance between the magnetic surface and the viewing plane.

The default viewing distance is 3mm but you can set it to different values. Each time you change the viewing distance, the vector field will need to be recalculated.

On the lower right hand side of the application is 'Add' button. It allows you to add a vector field stored in memory and a vector field stored using the 'Export' button. Ideally the more complex magnet arrays could be stored after plotting and then added to new designs to save computation times.

Pic2Mag Cache Files

Each time you observe a different color and z distance, the program computes new internal data structures and saves them to disk for later reuse. This doubles the program speed when you process that same color again!

But the cache files take up space on your hard drive and you can delete the files using the 'Clear' button on the middle right hand side of the program. If you are done computing vector fields then press 'Clear' button and then the 'yes' button to delete the temporary cache files. The program only creates cache files as they are needed and will produce smaller numbers of cache files, if the user uses a smaller set of colors and distances.

Parallel Processing with Pic2Mag's Field Calculator

The program is designed to be self contained and has about a 500 megabyte RAM memory footprint while processing. Other than writing a cache file when the file is not found, and reading cache files; the program has no temporary file operations meaning that you can run multiple copies of Pic2Mag's Field Calculator in the same program directory while sharing the same cache files.

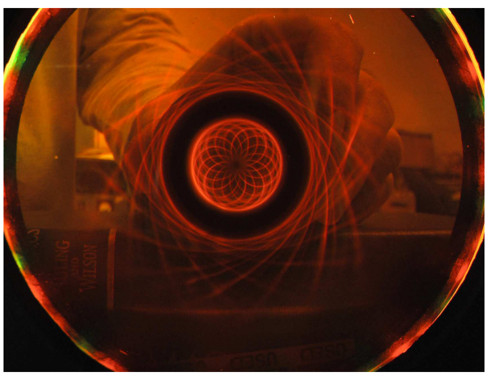
The Free Beta Version 1.0 uses four processor threads and is highly parallel both in the number of threads that it uses, and the number of program instances that can be ran from the same directory.

Pic2Mag's Field Calculator Pricing

The Free Beta Version 1.0 support four processor threads and may be used by everyone and shared with everyone; including professors, students, and school computer labs, but the program may not be resold.

Please email questions and bug reports to msnyder@pic2mag.com

Own your own copy of **Pic2Mag's Field Calculator** for $9.95. The paid version supports eight to twelve processor threads and is over two times faster and it has support for both printing and scanning images. It also supports thicker magnets.



Email msnyder@pic2mag.com for support and orders.

Pic2Mag Extended Color Table - Degree <Red,Green,Blue>

(When in doubt, put a small circle of the color in question on a black image and process it.)

0° <1,100,1>
1° <2,100,1>
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Pic2Mag Extended Color Table - Degree <Red,Green,Blue>

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Pic2Mag Extended Color Table - Degree <Red,Green,Blue>

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Pic2Mag Extended Color Table - Degree <Red,Green,Blue>

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Pic2Mag Extended Color Table - Degree <Red,Green,Blue>

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Pic2Mag Extended Color Table - Degree <Red,Green,Blue>

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